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A CHEMICAL AND BIOLOGICAL EVALUATION OF THREE MINE DRAINAGE TREATMENT PLANTS

ENVIRONMENTAL PROTECTION AGENCY

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A Chemical and Biological Evaluation

of Three

Mine Drainage Treatment Plants

Work Document No. 47

This document has been prepared to record a specific water pollution control activity carried out, to date, in the furtherance of the water pollution control program being developed in the subject basin. The information contained herein will serve as a ready reference to aid in the planning and development of the program in the basin, for appropriate in-service training of participating personnel, and facilitating program activities with other cooperating groups.

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SUMMARY

Chemical and biological sampling was conducted at three mine drainage treatment plants operating in Washington County, Pennsylvania. These treatment plants were operated by the Jones and Laughlin Steel Corporation at their Vesta No. 4 and Vesta No. 5 Mines. Although J & L operates other mine drainage treatment plants, those selected for this evaluation were the Bercik, Kefover and Thompson facilities. Each receiving tributary was unaffected by mine drainage above the location of the treatment plant.

A fourth site was selected as a control station. This site represented an untreated effluent from an active mine which discharged to a tributary unaffected by mine drainage above the selected point of discharge. This site was located on Little Indian Creek north of Rivesville, West Virginia.

Chemical samples were collected from four areas at each of the treatment plants. These points included the receiving stream both above and below the treatment plant and the untreated mine discharge as it was pumped from the borehole as well as the treated effluent prior to discharge to the receiving stream. Biological sampling of the receiving stream was conducted above the treatment plant, immediately below the final effluent, and below the plant. Similar sampling was also conducted at the control site. Sampling was conducted once a month at each of the four sites during the months of May, June, July and August 1972.

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In addition to the parameters generally associated with mine drainage, ten additional parameters were included for analysis during three of the four sampling rounds. These were all metals and included manganese, aluminum, calcium, magnesium, cadmium, chromium, copper, lead, nickel and zinc. These metals were included in a general attempt to observe the efficiency of a conventional mine drainage treatment plant for the removal or reduction of metals not commonly associated with mine drainage but often present in measurable quantities.

The effectiveness of the treatment plants in removing or reducing common mine drainage parameters was generally adequate. However, on occasion, two of these plants were responsible for the discharge of a final effluent which exhibited excessive concentrations of acidity, suspended iron and total iron.

The benthos in the receiving streams below each of the three plants were affected by the treated mine effluent. However, the adverse affects were much more noticeable below the two plants mentioned above where both acidity and iron concentrations were occasionally excessive.

In general, the chemical and biological data rank the three plants in the same order of effectiveness when the data is evaluated from either standpoint. This order of ranking is as follows:

Kefover Treatment Plant

Thompson Treatment Plant

Bercik Treatment Plant

CONCLUSIONS

1. The Kefover Treatment Plant was the most efficient of the three plants studied. The retention time in the sedimentation pond and the dilution capacity of the receiving stream were the principal features of this facility. The flow in the receiving stream was larger than the final Kefover effluent and diluted the residual chemical constituents to a more tolerable level. The benthos in the receiving stream were only slightly affected by the treated discharge. In addition to the conventional mine drainage parameters, copper and zinc were significantly reduced at this site. A raw water aluminum concentration was completely removed by the treatment procedure on both occasions when initially present.

2. From a chemical standpoint and under normal operating conditions, the Thompson Plant was probably as effective as the Kefover Plant in removing or reducing common mine drainage parameters. However, acid slugs can be discharged from this plant during some maintenance operations. As a result, the overall treatment capability was reduced. This was particularly evident with respect to the downstream benthos. An initial raw water aluminum concentration was completely removed on each occasion it was present. Significant reductions were noted in the concentrations of nickel and zinc and to a lesser degree for several other trace metals.

3. The Bercik Plant was the least efficient of the three facilities studied. The benthic community was severely depressed immediately below the discharge point and only slightly improved well below the discharge point. The limited dilution capacity of the receiving stream below the plant was a significant factor impairing the effectiveness of this operation. A suspended iron concentration, ranging from 2 mg/l to 6 mg/l in the final effluent, was primarily responsible for the poor aesthetic appearance of the receiving stream below the facility.

4. The inclusion of trace metals in the analyses of the various mine waters were not intended as part of the overall evaluation of the treatment plants under consideration. They were included only as an additional point of interest to determine what effects conventional lime neutralization would have on initial concentrations of various trace metals in raw mine water. In reviewing the limited amount of data collected during this survey, it is apparent that the concentrations of these metals can vary significantly from discharge to discharge or with varying time periods at the same discharge point. Perhaps if a particular trace metal was consistently present in significant quantities, the treatment plant operation could be adjusted to eliminate or reduce the metal in question. Under normal operating procedures, trace metal removal appears to be a function of the chemical make-up of the mine water and the type of treatment supplied.

5. When sludge removal is necessary, it should be done frequently enough so that the retention time is consistently long enough to permit the sedimentation of nearly all suspended solids.

RECOMMENDATIONS

1. Any similar study should be conducted with an increased number of both biological and chemical samples. The sampling period should represent at least three seasons of the year. If artificial substrates are used, they should be exposed for eight weeks instead of four. The benthos, where practical, should be identified to genus. Chemical sampling should be conducted on a weekly basis rather than monthly.

2. In addition to other treatment plant construction considerations, it is recommended that consideration be given to the size of the available receiving stream. This stream should be large enough to dilute the treated effluent to a level which can be tolerated by the benthos, plankton and fish.

3. Treatment plants should be designed so that acid slugs are not released to the receiving stream when maintenance operations or equipment failures occur at the facilities. When the raw water or treated water ponds require sludge removal, a second pond should be available for temporary use during the maintenance operation.

4. The water quality of streams below new treatment plants should be comparable to or better than the water quality conditions exhibited in the receiving streams below the Kefover and Thompson Treatment Plants.

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5. This study was not performed in a detailed manner and can only serve to grossly evaluate the three treatment plants. The chemical and biological data and related observations made during this survey can serve as an aid in planning other such studies and in designing future treatment plants.

INTRODUCTION

In September of 1971, a work activity was formulated at the Wheeling Field Office, Surveillance and Analysis Division, Region III, Environmental Protection Agency, which involved a program for updating the number of active underground coal mining operations in the Monongahela River basin. An earlier study had been conducted prior to 1965 which involved all types of mining operations both active and abandoned. Between 1965 and 1971, significant changes had occurred, particularly with respect to the number of underground mines still in operation. A resurvey of the active underground mines in the Monongahela River basin was initiated in November 1971 and was completed in December 1972. The results of this survey are published in Work Document No. 46, "The Status of Active Deep Mines in the Monongahela River Basin."

During the inventory, it was found that many of the mines, particularly in Pennsylvania, were supplying some type of treatment to their mine drainage effluent prior to discharge. Single samples collected at these treatment plants generally indicated that common mine drainage parameters were removed or reduced with a high degree of efficiency. For this reason, it was decided to conduct additional sampling at several mine drainage treatment plants in order to more accurately assess the operational efficiency of these facilities.

At the outset of the study, it was decided not to limit the survey to the collection of samples only for chemical water quality analyses. Benthic organisms are frequently used in water pollution surveys as water quality indicators because they are relatively stationary organisms. A survey of benthic organisms provides a gross analysis of water quality in a given area of stream. For this reason, samples for both water quality and biological analyses were collected at selected points at each of the treatment plant sites. This will provide a separate chemical and biological evaluation at each of the treatment plant sites.

SURVEY DESCRIPTION

Selection of the mine drainage treatment plants was based on several factors including location, quantity and quality of mine effluent, and travel time between sites. In the final selection, three sites, operated by the Jones and Laughlin Steel Corporation, were chosen for the study. A letter of request was submitted to the appropriate Jones and Laughlin official and permission was obtained to visit the sites as required. No time period was allotted for our sampling run and personnel from the Wheeling Field Office were able to visit the treatment plant sites at any time during the course of study. The three selected sites were the Bercik, Kefover and Thompson mine drainage treatment plants.

A fourth site was also selected as a control station. This site represented an untreated effluent from an active mine which discharges to a tributary unaffected by mine drainage above the selected point of discharge. This site was located on Little Indian Creek north of Rivesville, West Virginia.

FIELD PROCEDURES - CHEMICAL SAMPLING

With respect to relative location, identical sampling points were selected at each treatment plant site. A background sampling point was selected at each site above the treatment plant. Since each receiving tributary was unaffected by either active or abandoned mine drainage, the sampling point was indicative of the natural unaltered stream water quality. Additional sampling points included the raw mine water before treatment and also the final effluent representing the quality of water discharged to the receiving stream. A fourth sample was collected from the receiving stream a short distance below the point where the final effluent entered that particular receiving stream.

A total of four samples were collected at each site. This represented one complete round at each site during the months of May, June, July and August of 1972. During the May sampling round, the collected samples were analyzed for conventional mine drainage parameters. These parameters included acidity, alkalinity, sulfates, dissolved iron and suspended iron. The total iron concentration was obtained by combining the dissolved and suspended iron components.

During the subsequent samplings, ten additional parameters were determined for each site. These parameters included manganese, aluminum, calcium, magnesium, cadmium, chromium, copper, lead, nickel and zinc. Analyses for these metals were considered in a general attempt to further evaluate the efficiency of a conventional mine drainage treatment plant for the removal or reduction of metals not commonly associated with mine drainage but often present in measurable quantities.

FIELD PROCEDURES - BIOLOGICAL SAMPLING

Changes in water quality produce different responses from different aquatic organisms. There are some aquatic organisms which can survive and flourish in heavily polluted waters and there are other organisms which cannot survive in waters even slightly polluted. This is true of benthos, plankton and fish. Benthic organisms are used frequently in water pollution surveys as water quality indicators because they are relatively stationary organisms. Fish and plankton can be less effective in demonstrating pollution conditions than the benthos because fish may avoid polluted water by swimming away and the plankton effects may not be readily measured because of stream drifting.

A survey of the benthic organisms provides a gross analysis of water quality in a given area of stream. By using biological data and descriptions, one can delineate sections of a stream into unpolluted zones capable of supporting a varied population of aquatic organisms and polluted zones which support altered aquatic communities.

Three sampling stations were set up at each of the four sites. The first station at each site was located upstream of the discharge. This station is a reference or background station. The second station at each site was located below the discharge. The proximity of the station to the discharge was dependent on substrate conditions. The purpose of this station was to measure the maximum impact of the discharge on the benthic community. The third station at each site was located at a distance below the discharge to insure that the receiving stream and the discharge were completely mixed. This station measured the general impact of the discharge on the stream and also gave some indication of any immediate downstream recovery.

Bottom samples were collected once at each of the twelve stations. A Surber square foot sampler was used and samples were all collected in shallow riffle areas. The material collected was placed in quart jars and preserved for transportation to the laboratory, where the organisms were separated and identified. Multi-plate artificial substrates were also utilized for the biological study. These samplers were similar to the one described in the 13th edition of Standard Methods (1). The sampler exposes approximately one square foot of surface area for the attachment of organisms.

Two multi-plate samplers were suspended in the water column at each of the twelve stations. The exposure period for the samplers was approximately one month and three exposure periods were used at each station. These samplers were suspended both vertically and

horizontally in the water column.

At the end of the exposure period, the samplers were carefully removed from the water, detached from their holding devices, and placed in one gallon buckets filled with a five percent solution of formalin. The samplers were taken to the laboratory, disassembled, brushed with a stiff bristle brush, and the organisms were concentrated in a U. S. Standard No. 30 sieve.

Each sample was sorted, counted and identified. The identification of the insects, clams and crustaceans was carried to the family taxonomic level. All the other groups were identified to the class or order taxonomic level except the Phylum Nematoda. The Family Hydridae was counted as a taxonomic group but the number of these collected at any given station was not counted in the total number of organisms collected at that station.

The taxa collected were divided into three classes based on their tolerance to mine drainage. The three classes are as follows: Class I, organisms intolerant of mine drainage; Class II, organisms which are tolerant to some constituents of mine drainage to some degree; Class III, organisms which are tolerant to mine drainage. The classification of the taxonomic groups, as described in this report, is preliminary and any reference made to this classification system should identify it as such. This system will be revised and updated as more information is gained and more data is collected. The classification system used in this report is based on observed tolerances

of the various groups as reported in the literature, i. e., Griffith (2), Reppert (3), Dinsmore (4), etc., and upon personal observations of various benthic associations encountered in both affected and unaffected water. Published and unpublished data developed by the Wheeling Field Office was also used in establishing the system.

A diversity index was applied to samples collected as a matter of interest to see how such an index would relate to the observed results. The following index, taken from Wilhm (5) was used:

$$d = \frac{s-1}{LnN}$$

Where d is the diversity index, s is the number of taxa and LnN is the natural logarithm of the number of individuals per sample. The larger the diversity index, the better the water quality, because the diversity index represents the wealth of taxa as related to total number of organisms per sample. Maximum diversity exists if each individual is in a different taxa and minimum diversity exists if all individuals belong to the same taxa.

STATE REQUIREMENTS

The Pennsylvania Department of Environmental Resources requires active mine discharges to meet effluent guidelines imposed by the Commonwealth. In general, these requirements limit the pH value to between 6.0 and 9.0 standard units, require a total iron concentration of 7 mg/l or less, and require a final effluent exhibiting net alkalinity.

Although these are the effluent criteria imposed by the Commonwealth on active underground mine discharges under the 1965 amended Clean Streams Law, the water quality standards of the receiving stream are also of prime importance in determining the compliance status of a particular mine drainage discharge. A 1.5 mg/l total iron concentration has been adopted by the Commonwealth for streams in the Pennsylvania portion of the Monongahela River basin.

A permit is required from the DER for each point of mine drainage discharge from an active mine. The effluent requirements for each discharge are specified in the permit. As conditions require, the discharge may exceed the guidelines listed above or conversely it may require more restrictive limitations. The DER may also require limitations on other mine drainage parameters such as aluminum, manganese, sulfates, etc., as deemed necessary.

DESCRIPTION OF SITES

The three Jones and Laughlin treatment plants were located in

Washington County, Pennsylvania. The Bercik plant was located on an unnamed tributary to Pike Run which, in turn, is a tributary to the Monongahela River near the community of Coal Center. The Kefover plant was located on Daniels Run and the Thompson plant was located on Plum Run. Both Daniels Run and Plum Run are tributaries to Tenmile Creek, which enters the Monongahela River at Millsboro, Pennsylvania.

The control site representing an active untreated discharge was located on Little Indian Creek, a tributary to Indian Creek which joins the Monongahela River at Everettville, West Virginia.

The tributaries on which these four sites are located are unaffected by any active or abandoned mine discharges along the entire length of stream under consideration.

BERCIK TREATMENT PLANT

This facility provided lime neutralization followed by aeration and sedimentation. Acidity was not a major problem in the raw mine water effluent; however, the initial iron concentration was excessive. At an earlier visit to this site (12/71), only sedimentation and mechanical aeration were supplied. However, at the time of the first sampling for this study, the facility had been upgraded by the installation of the lime addition apparatus and an electrical aerator.

After alkalinization and aeration, the effluent was gravity fed to a series of three sedimentation ponds. The final effluent from the third pond is discharged to an unnamed tributary of Pike Run (Figure 1).

During the period of sampling, this mine effluent was characterized by a comparatively large discharge which averaged 1,928 gpm. The alkalinity concentration of the raw effluent generally exceeded the acidity concentration and the total iron concentration was 50 mg/l or less.

The chemical and biological sampling points associated with the Bercik mine drainage treatment plant are shown in Figure 1. Table 1 lists the chemical data collected during the four sampling periods.

CHEMICAL EVALUATION

The raw water pumped to the surface at the Bercik borehole was alkaline on three of the four sampling occasions. However, the total iron concentration ranged from 20 to 50 mg/l. This initial total iron concentration was reduced by treatment to a range of 3 to 6 mg/l in the final effluent. It is noteworthy that the dissolved iron portion of this total iron concentration averaged only 0.5 mg/l while the suspended iron fraction accounted for the major portion of the iron which was measured. There was no suspended iron present in the untreated raw water discharge, and the final effluent exhibited a suspended iron concentration ranging from 2 to 6 mg/l.

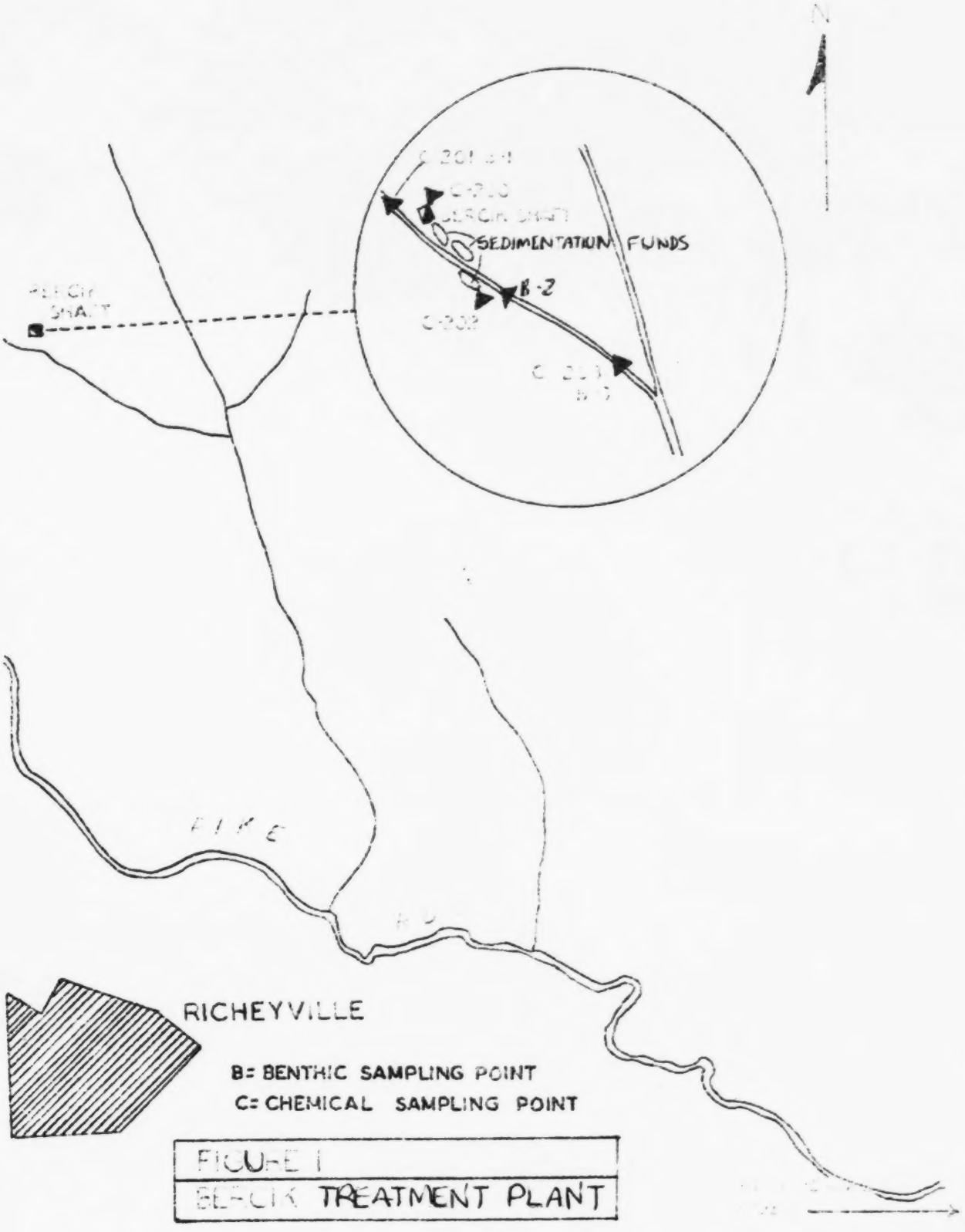

FIGURE 1
BE-CIK TREATMENT PLANT

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Table 1

Water Quality Data

Bercik Treatment Plant

	Background (C-201)				Untreated Discharge (C-200)				Treated Discharge (C-202)				Downstream (C-203)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
pH	6.9	7.3	7.7	7.5	6.6	6.9	7.1	7.0	6.4	7.4	7.3	7.1	7.5	7.7	7.5	7.4
Specific Conductance	570	600	520	650	2300	2500	3000	2700	2800	2800	2700	2600	2500	2500	2700	2600
Flow-gpm	-	-	-	-	-	-	-	-	2240	1885	1508	2080	-	2806	3018	-
Net Alkalinity mg/l	-61*	175	194	-	-177	81	39	203	47	82	130	244	112	75	120	222
Dissolved Iron-mg/l	0	0	0	1	50	50	20	45	1	1	0	0	0.5	0.5	0	0
Suspended Iron-mg/l	0.5	1	0	0	0	0	0	0	4	2	2	6	3.5	2.5	3	6
Total Iron mg/l	0.5	1	0	1	50	50	20	45	5	3	2	6	4	3.0	3	6
Sulfate mg/l	45	65	55	120	1530	825	900	750	1365	850	930	775	1380	775	960	750
Manganese mg/l	-	0.1	4	0	-	5	5	4	-	5	4	4	-	5	4	5
Aluminum mg/l	-	0	0	0	-	0	0	1	-	0	0	0	-	0	0	0

*Negative value denotes acidity.

Table 1 (continued)

Water Quality Data

Bercik Treatment Plant

	Background (C-201)				Untreated Discharge (C-200)				Treated Discharge (C-202)				Downstream (C-203)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
Calcium mg/l	-	55	50	60	-	200	200	300	-	200	200	320	-	200	200	300
Magnesium mg/l	-	17	[illegible]	20	-	70	50	65	-	60	60	60	-	50	50	65
Cadmium ug/l		0	0	0	-	10	20	21	-	10	20	16	-	10	20	19
Chromium ug/l	-	0	[illegible]	[illegible]	-	20	0	41	-	10	20	25		0	0	36
Copper ug/l	-	0	50	8	-	0	0	10		0	0	0	-	0	50	10
Lead ug/l	-	0	0	20	-	20	0	60	-	20	0	20	-	40	0	20
Nickel ug/l	-	20	40	5	-	70	80	60	-	50	40	42	-	50	0	55
Zinc ug/l	-	10	0	0	-	20	20	22	-	20	20	13	-	10	20	20

The three large sedimentation ponds at Bercik have been in operation for 7 or 8 years. During this time, sludge removal has been somewhat minimal due to the large area available for sedimentation. However, the long-term accumulation of sediment (iron floc) was becoming a problem at the Bercik site. In the treatment process, the dissolved iron is converted to the insoluble state for precipitation. However, due at least in part to the chemical composition of the mine water before and after treatment and the reduced capacity of the available sedimentation area, a significant portion of the iron concentration was discharged to the receiving stream in the suspended state.

As would be expected from the above discussion, the total iron concentration carried by the receiving stream (C-203) below the Bercik discharge, represented a significant increase in comparison with the total iron concentration exhibited by the background sampling point (C-201) above the Bercik discharge. The background total iron concentrations ranged from 0 mg/l to 1 mg/l and the downstream values ranged from 3 to 6 mg/l. This iron was generally present in the form of ferric hydroxide and/or ferric sulfate which were responsible for staining and coating the banks and bottom of a downstream length of the receiving tributary.

The alkalinity concentration of the receiving stream was reduced by the Bercik discharge on two of the four sampling occasions. However, on one occasion the alkalinity was increased. There were no significant

changes in the pH values of the receiving stream below the Bercik outfall. As expected, the sulfate concentrations in the receiving stream were greatly increased. At the upstream point, the sulfate values ranged from 45 to 120 mg/l while the downstream point values ranged from 750 mg/l to 1,380 mg/l.

BIOLOGICAL EVALUATION

Descriptions of the three biological sampling stations associated with the Bercik treatment plant are given below. Tables 2, 3 and 4 represent the biological data collected at these points.

The number of organisms and taxa collected at the two downstream stations was well below the numbers collected at the upstream station. The following is a more detailed description of the results obtained at each station.

Station B-1 (Upstream of Discharge)

The substrate at this station was composed of a mixture of rock, rubble, gravel and sand (Table 2). Stream bottom conditions appeared to be very stable. The number of taxa collected at this station, 21, (Table 3) was the most collected at any of the stations during the study and also yielded the highest diversity index of 3.50. The organisms were well distributed among several taxonomic groups. Eleven Class I taxa and nine Class II taxa were collected; however, there was a total of 147 Class II organisms (Figure 5) and 106 Class I organisms.

Table 2
Benthos Sampling Stations
Bercik Treatment Plant

Station Number	Sampling Dates	Station Location	Substrate Description	Comments
B-1	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	X-Trib. to Pike Run approximately 275 yards above the discharge.	Riffle Areas* 10% Rock 20% Rubble 20% C.Gravel 20% F.Gravel 20% C.Sand 10% F.Sand Pool Areas Consisted mainly of bedrock	The dendys collected on 7/24 were knocked over and laying on their side
B-2	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	X-Trib. to Pike Run approximately 30 yards below the discharge.	Riffle Area 10% Rock 5% Rubble 50% C.Gravel 15% F.Gravel 10% C.Sand 10% F.Sand Pool Areas Mostly bedrock with some gravel.	
B-3	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	X-Trib. to Pike Run approximately 300 yards below the discharge.	Riffle Areas 5% Rock 5% Rubble 50% C.Gravel 30% F.Gravel 10% C.Sand 10% F.Sand Pool Areas Bottoms consisted mainly of clay and gravel.	One dendy collected on 7/24/ had been knocked over and was laying on its side.

*Bottom compositions are estimates based on field observations.

Table 3

Benthos Data Summary
Bercik Treatment Plant

Station Number	Sampling Dates	No. of Samples	Type of Sample	Total No. of Organisms	No. of Taxa collected	Diversity Index	% of Class I	% of Class II	% of Class III
B-1	5/16	1	S *	301	21	3.50	35	49	16
	5/16 to 6/16	1	D **	76	4	0.70	0	3	97
	5/16 to 6/16	1	D	28	1	Ø	0	0	100
	6/16 to 7/24	1	D	66	5	0.95	6	6	88
	6/16 to 7/24	1	D	93	8	1.54	4	4	92
	7/24 to 8/21	1	D	9	1	Ø	0	0	100
	7/24 to 8/21	1	D	28	5	1.20	11	46	43
B-2	5/16	1	S	16	3	0.72	6	44	50
	5/16 to 6/16	1	D	225	3	0.62	12	12	76
	5/16 to 6/16	1	D	59	6	1.23	7	66	27
	6/16 to 7/24	1	D	1	1	Ø	0	100	0
	6/16 to 7/24	1	D	55	4	0.75	2	94	4
	7/24 to 8/21	1	D	0	0	Ø	0	0	0
	7/24 to 8/21	1	D	1	1	Ø	0	0	100
B-3	5/16	1	S	45	9	2.10	11	31	58
	5/16 to 6/16	1	D	6	3	0.56	17	17	66
	5/16 to 6/16	1	D	4	1	Ø	0	0	100
	6/16 to 7/24	1	D	7	5	2.09	0	71	29
	6/16 to 7/24	1	D	11	7	2.50	27	64	9
	7/24 to 8/21	1	D	1	1	Ø	0	0	100
	7/24 to 8/21	1	D	0	0	Ø	0	0	0

* Surber Samples
** Artificial Substrate Samples

Table 4
Benthos Data
Bercik Treatment Plant

Class I	B-1a	B-1b	B-1b	B-1c	B-1c	B-1d	B-1d	B-2a	B-2b	B-2b	B-2c	B-2c	B-2d	B-2d	B-3a	B-3b	B-3b	B-3c	B-3c	B-
Caddisflies																				
Hydroptilidae	11														3					
Philopotamidae	1																			
Psychomyiidae	2																			
Stoneflies																				
Perlidae	1									1					2	1				
Perlodidae	1																			
Mayflies																				
Heptageniidae	33				2															
Crustaceans																				
Astacidae	1				1															
Isopoda	43			1															1	
Flatworms																				
Turbellaria	5									3		1							1	
Roundworms																				
Nematoda	1							1	3										1	
Fingernail Clams																				
Sphaeriidae				3	1															
Crane Flies																				
Tipulidae	7																			
Leeches																				
Hirudinea							3													
Class II																				
Caddisflies																				
Hydropsychidae	47							7		32	1	15			1			2		

Table 4

Benthos Data
Bercik Treatment Plant

Continued

Class II (cont'd)	B-1a	B-1b	B-1b	B-1c	B-1c	B-1d	B-1d	B-2a	B-2b	B-2b	B-2c	B-2c	B-2d	B-2d	B-3a	B-3b	B-3b	B-3c	B-3c
Stoneflies																			
Nemouridae	24														1				
Mayflies																			
Baetidae	30	1			1														
Beetle Larvae																			
Elmidae	6														1			1	
Dryopidae	1																		
Dytiscidae				3															
Hydrophilidae																		1	
Crustaceans																			
Amphipoda	34				1					6		37			8			1	4
Snails																			
Pulmonata					1		1												
Dance Flies																			
Empididae	2														2				
Black Flies																			
Simuliidae	1																		
Horse Flies																			
Tabanidae					1														
Damselflies																			
Coenagrionidae							1												
Aquatic Worms																			
Oligochaeta	2			1			11		3	1					1	1		2	1

Table 4
Benthos Data
Bercik Treatment Plant

Continued

Class III	B-1a	B-1b	B-1b	B-1c	B-1c	B-1d	B-1d	B-2a	B-2b	B-2b	B-2c	B-2c	B-2d	B-2d	B-3a	B-3b	B-3b	B-3c	B-3c	I
Megaloptera																				
Sialidae		2																		
Midge Flies																				
Chironomidae	48	72	28	58	85	9	12	8	19	16		2		1	26	4	4	2	1	

The benthic community at this station is what one would expect to collect in a small stream with good water quality.

Station B-2 (30 yards below discharge)

About 65 percent of the substrate at this station was gravel (Table 2) with the remainder being a combination of rock, rubble and sand. Red stains were present on the substrate and suspended iron particles produced a reddish tint in the water. Only 16 organisms and 3 taxa (Table 3) were collected at this station. Class I organisms were reduced in number from 106 at Station B-1 to one at Station B-2 and from 11 taxa at Station B-1 to one taxon at Station B-2. Class II organisms were similarly reduced in number and taxa. At Station B-1, there were 147 Class II organisms in 10 taxa and at Station B-2 there were 7 organisms in one taxa. The number of Chironomidae were reduced from 48 at Station B-1 to 8 at Station B-2. The total numbers and variety of the benthic community at this station was severely depressed. The substrate may be partly attributable for the poor macroinvertebrate community, however, the major problem is the degradation of the stream water quality by the discharge, indicating a toxic effect.

Station B-3

The substrate at this station was not favorable for aquatic life as it was composed of about 80 percent gravel with very little rock and rubble. Suspended iron particles were also visible in the water

at this Station and the substrate was stained red. The benthic community was slightly improved over the one at Station B-2; however, it still did not begin to compare with the benthic community found at the background station. There was a total of 45 organisms and 9 taxa collected at this station with a resulting diversity index of 2.10. The number of taxa in Class II increased from one at Station B-2 to six at this station and the number of Class II organisms was doubled. The number of Chironomidae increased from 8 at Station B-2 to 26 at Station B-3. Class I organisms also showed some small increase by 4 individuals and one taxon. The small increase in total organisms and the number of taxa from Station B-2 to Station B-3 appears to be influenced by substrate composition because the water quality at both stations is nearly identical.

KEFOVER TREATMENT PLANT

The Kefover mine drainage treatment plant is located on Plum Run just north of the community of Marianna, Pennsylvania. Raw mine water is pumped to the surface and channelled to a single large sedimentation pond. Lime is slurry fed to the effluent prior to discharge to the sedimentation pond. The existing system was somewhat temporary and an upgraded facility was under construction at the time of survey. The upgrading will probably be primarily directed toward an increase in capacity of the lime holding tank and a decrease in maintenance time required for plant operation. However, the system in use was quite adequate with respect to the production of a final discharge exhibiting satisfactory water quality.

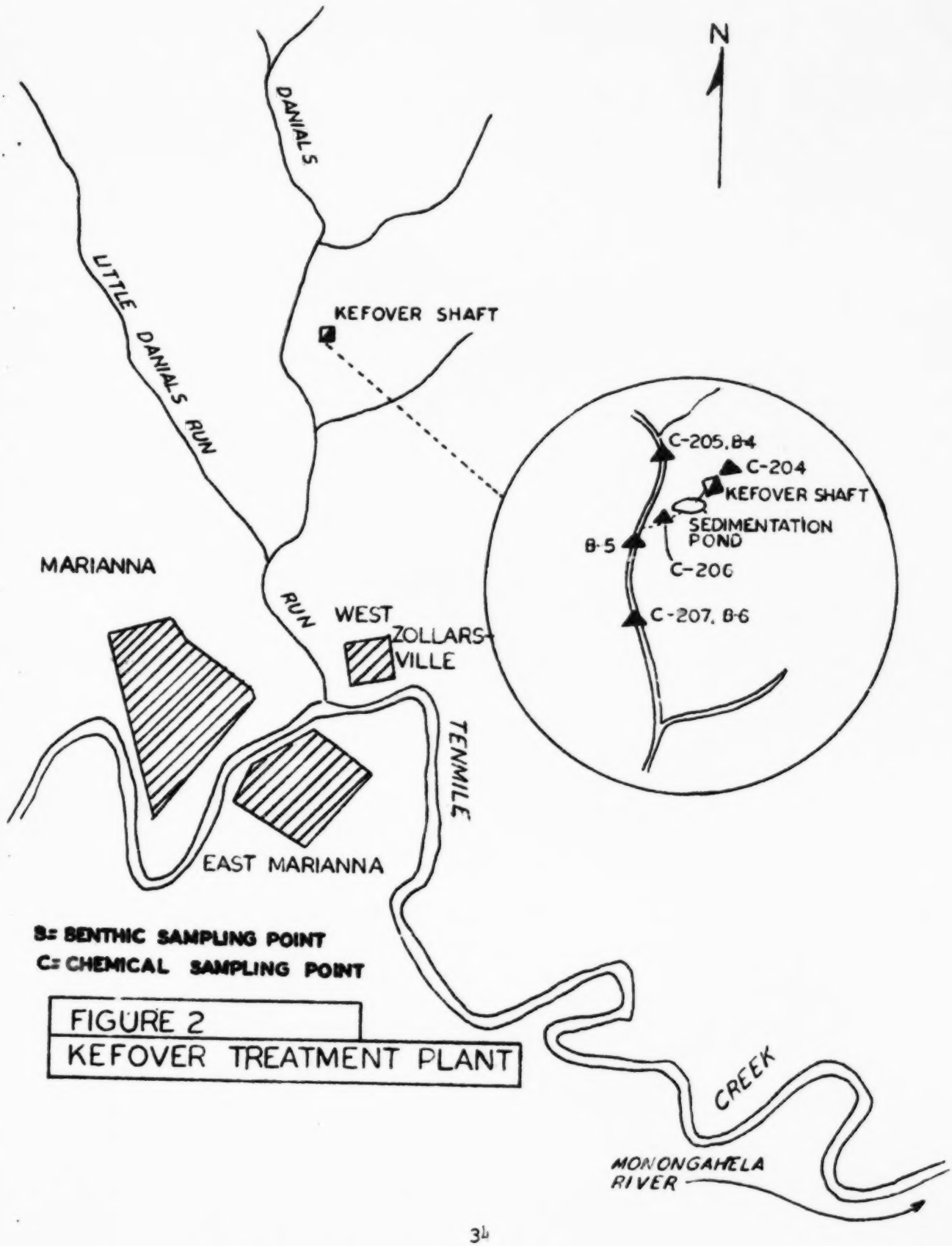
The chemical and biological sampling points associated with the Kefover site are shown in Figure 2. Table 5 lists the chemical data collected during the four sampling periods.

CHEMICAL EVALUATION

The acidity concentration of the raw water discharge at the Kefover site ranged from 100 mg/l to 610 mg/l for three samples. On the fourth sampling, the discharge exhibited a net alkalinity of 95 mg/l. The total iron concentration of the untreated effluent ranged from 15 mg/l to 60 mg/l. Suspended iron was present in three of the four samples.

The treated Kefover discharge exhibited an average net alkalinity of 111 mg/l during the sampling period. The corresponding pH values ranged from 6.8 to 7.1. An average discharge rate of 168 gpm was measured at this plant.

Iron removal at the Kefover site was quite adequate. On one occasion, the treated effluent exhibited a total iron concentration of 3 mg/l; however, during the other sampling periods, the iron concentration averaged only 0.3 mg/l. As a result of the neutralization process, the sulfate concentration averaged 1,875 mg/l in the treated discharge. On two of the three samples, where the presence of aluminum was detected, initial raw water concentrations of 45 mg/l and 24 mg/l were both reduced to zero by the treatment process. Initial concentrations of such trace metals as cadmium, copper and zinc were



B= BENTHIC SAMPLING POINT
C= CHEMICAL SAMPLING POINT

FIGURE 2
KEFOVER TREATMENT PLANT

Table 5
Water Quality Data
Kefover Treatment Plant

	Background (C-205)				Untreated Discharge (C-204)				Treated Discharge (C-206)				Downstream C-207)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
pH	6.8	7.3	7.8	7.8	4.6	4.5	6.7	5.5	6.8	6.9	7.0	7.1	7.7	7.5	8.0	7.5
Specific Conductance	550	650	540	650	7000	8000	8000	8000	8000	8000	7400	8000	1400	1200	1000	2100
Flow-gpm	-	-	-	-	-	-	-	-	-	174	180	150	2406	1132	2120	-
Net Alkalinity-mg/l	168	142	194	-	-610*	-590	95	-100	135	30	90	188	78	106	182	209
Dissolved Iron-mg/l	0.5	0.3	0	0	25	15	15	40	0.3	0.5	0	0.2	0.3	1	0	0
Suspended Iron-mg/l	0	0	0	0	35	11	0	18	0.2	0	3	0	0	0	0	0
Total Iron mg/l	0.5	0.3	0	0	60	25	15	58	0.5	0.5	3	0.2	0.3	1	0	0
Sulfate mg/l	65	60	65	70	3375	2100	1700	2300	2800	2100	1200	1400	255	310	200	560
Manganese mg/l	-	0	3	0	-	7	0	5	-	6	0	3	-	1	7	0
Aluminum mg/l	-	0	0	0	-	45	0	24	-	0	0	0	-	0	0	0

*Negative value denotes acidity.

Table 5
Water Quality Data
Kefover Treatment Plant

(continued)

	Background (C-205)				Untreated Discharge (C-204)				Treated Discharge (C-206)				Downstream C-207)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/7
Calcium mg/l	-	50	50	120	-	200	210	390	-	200	300	80	-	75	70	150
Magnesium mg/l	-	10	10	12	-	25	75	100	-	115	75	85	-	15	15	30
Cadmium ug/l	-	5	0	70	-	20	20	560	-	5	0	42	-	0	0	20
Chromium ug/l	-	0	0	0	-	30	20	18	-	0	20	80	-	0	0	20
Copper ug/l	-	5	0	0	-	100	100	65	-	5	0	20	-	0	0	25
Lead ug/l	-	0	0	-	-	50	0	30	-	20	0	20	-	0	0	20
Nickel ug/l	-	10	0	5	-	500	100	450	-	400	100	300	-	50	0	36
Zinc	-	10	20	7	-	700	300	580	-	200	70	40	-	40	20	15

reduced to a lower level of concentration by the treatment process.

At the upstream sampling point (C-205), the pH value ranged from 6.8 to 7.8 and exhibited an average net alkalinity of 168 mg/l. At the stream sampling point below the Kefover discharge (C-207), the pH value ranged from 7.5 to 8.0 and exhibited an average net alkalinity of 144 mg/l. During the period of sampling, there was no significant increase in the total iron concentration carried by the receiving stream. Above the discharge point, the tributary carried an average iron concentration of 0.2 mg/l and below the discharge, the average was 0.3 mg/l. Sulfate values averaged 65 mg/l at the background station and 341 mg/l at the downstream sampling point.

BIOLOGICAL EVALUATION

Descriptions of the three biological sampling stations associated with the Kefover plant are given below. Tables 6, 7 and 8 present the biological data collected at these points.

The total number of organisms collected at the three stations (Figure 6) declined in downstream order; however, the diversity indices for the three stations remained relatively constant. The principle group collected at the stations was the dipteran family, Chironomidae. The following is a more detailed description of the results obtained at each station.

Table 6
Benthos Sampling Stations
Kefover Treatment Plant

Station No.	Sampling Dates	Station Location	Substrate Description	Comments
B-4	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	Daniels Run approximately 200 yards upstream of the discharge.	Riffle Areas* 10% rock 30% rubble 30% C.Gravel 10% F.Gravel 10% C.Sand 10% F.Sand Pool Areas Bottoms consisted mainly of "bedrock"	The dendy, the last collected 7/24, had been moved about 25 feet downstream by the current.
B-5	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	Daniels Run approximately 50 yards below the discharge.	Riffle Areas 10% rock 50% rubble 20% C.Gravel 10% F.Gravel 10% C.Sand Pool Areas Bottoms consisted mainly of "bedrock"	
B-6	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	Daniels Run approximately 450 yards below the discharge.	Riffle Areas 10% rock 30% rubble 10% C.Gravel 10% F.Gravel 20% C.Sand 20% F.Sand Pool Areas Bottoms consisted mainly of "bedrock"	

*Bottom compositions are estimates based on field observations.

Table 7
Benthos Data Summary
Kefover Treatment Plant

Station Number	Sampling Dates	No. of Samples	Type of Sample	Total No. of Organisms	No. of taxa collected	Diversity Index	% of Class I	% of Class II	% of Class III
B-4	5/16	1	S*	440	18	2.79	41	15	44
	5/16 to 6/16	1	D**	93	3	0.44	0	2	98
	6/16 to 7/24	1	D	30	3	0.58	3	7	90
	7/24 to 8/21	1	D	52	3	0.50	0	4	96
B-5	5/16	1	S	338	15	2.40	58	17	25
	5/16 to 6/16	1	D	108	4	0.64	0	4	96
	5/16 to 6/16	1	D	182	6	0.96	1	7	92
	6/16 to 7/24	1	D	107	3	0.43	0	13	87
	7/24 to 8/21	1	D	28	1	Ø	0	0	100
	7/24 to 8/21	1	D	59	2	0.25	0	2	98
B-6	5/16	1	S	246	15	2.54	10	25	65
	5/16 to 6/16	1	D	78	4	0.69	1	3	96
	5/16 to 6/16	1	D	88	1	Ø	0	0	100
	6/16 to 7/24	1	D	47	1	Ø	0	0	100
	7/24 to 8/21	1	D	32	1	Ø	0	0	100

*Surber Samples

**Artificial Substrate Samples

Table 8
Benthos Data
Kefover Treatment Plant

Class I	B-4a	B-4b	B-4c	B-4d	B-5a	B-5b	B-5b	B-5c	B-5d	B-5d	B-6a	B-6b	B-6b	B-6c	B-6d
Caddisflies															
Hydroptilidae	140				182						13				
Philopotamidae	21				8						6				
Psychomyiidae			1				1								
Heliopsychidae	1														
Stoneflies															
Perlidae	4				6						3	1			
Mayflies															
Heptageniidae	6										3				
Crustaceans															
Isopoda	2														
Flatworms															
Turbellaria	4														
Roundworms															
Nematoda	1														
Fingernail Clams															
Sphaeriidae					1										
Crane Flies															
Tipuliidae	1														
Coelenterates															
Hydridae						-	-					-			
Class II															
Caddisflies															
Hydropsychidae	7			1	18		2	13			5				

*The numbers of these organisms were not counted.

Table 8
Benthos Data
Kefover Treatment Plant

Continued

Class II (cont'd)	B-4a	B-4b	B-4c	B-4d	B-5a	B-5b	B-5b	B-5c	B-5d	B-5d	B-6a	B-6b	B-6b	B-6c	B-6d
Stoneflies															
Nemouridae	1				1						2				
Mayflies															
Baetidae	17		2	1	4	1					22				
Megaloptera															
Corydalidae					1						1				
Biting Midge															
Ceratopogonidae	1														
Beetle Larvae															
Elmidae	15				17						19				
Psephenidae											2				
Crustaceans															
Amphipoda	1				2										
Snails															
Pulmonata							1				1				
Black Flies															
Simuliidae	9				6						7				
Dance Flies															
Empididae					5			1			2				
Damselfly															
Agrionidae										1					
Aquatic Worms															
Oligochaeta	17	2			3	3	11				1	2			

Table 8
Benthos Data
Kefover Treatment Plant

Continued

Class III	B-4a	B-4b	B-4c	B-4d	B-5a	B-5b	B-5b	B-5e	B-5d	B-5d	B-6a	B-6b	B-6b	B-6c	B-6d
Megaloptera															
Sialidae		1													
Midge Flies															
Chironomidae	192	90	27	50	84	104	167	93	28	58	159	75	88	47	32

Station B-4 (upstream of discharge)

The substrate at this station was stable and consisted primarily of rubble and gravel (Table 6). There was no evidence of any siltation problems. The principle land use above this station was agricultural with its associated housing. The stream was organically enriched as indicated by an abundant growth of algae attached to the surface of the substrate. This growth provided a habitat for the large numbers of Hydroptilidae and Chironomidae larvae collected at this station. There was a total of nine taxa at this station in Class I and eight taxa in Class II with one group in Class III.

Station B-5 (50 yards below discharge)

The physical characteristics of this station were almost identical to Station 4. The substrate material at this station was also coated with a thick growth of algae. The total number of organisms and the number of taxa collected at this station were less than those found at Station B-4. Although the percentage of Class I organisms increased at Station B-5, the number of taxa in Class I was reduced from 9 at Station B-4 to four at Station B-5. The increase in Class I organisms is due totally to the numbers of Hydroptilidae. The discharge affects all the Class I organisms except the Hydroptilidae and Perlidae. The organisms in Class II were reduced in number by only 8 and gained one taxon; they were not greatly affected by this discharge. The large reduction in the number of midge is the major difference in total numbers of organisms between Station B-4 and Station B-5. The

bar graphs representing numbers shown on Figure 5 do not accurately express the impact of the discharge on the stream due to the large number of Hydroptilidae.

Station B-6 (450 yards below discharge)

The substrate at this station consisted mostly of various sands and rubble. There was not a dense algal growth on the substrate as there was at Stations B-4 and B-5. The total number of organisms at this station was reduced further while the number of taxa remains the same as Station B-5 and only three less than Station B-4. The percentage composition by Class differs greatly with those at Stations B-4 and B-5. The substrate at this station affects the benthic fauna as much as the discharge itself. The great reduction in the Hydroptilidae population is the significant difference in Class I organisms at this station as opposed to the upstream stations, and this can be attributed to the loss of habitat rather than any changes in water quality. No significant differences are present between this station and Stations B-4 and B-5 in relation to the Class II organisms.

THOMPSON TREATMENT PLANT

This lime neutralization facility is located on an unnamed tributary to Plum Run which, in turn, joins Tenmile Creek near the community of Fairfield, Pennsylvania. The raw mine water is pumped to a holding pond above the treatment plant. From this point, the

mine water is piped through the plant. Additional mixing and some aeration of the alkalinized effluent is supplied by a V-notched baffling device prior to discharge to a single sedimentation pond. A portion of the treated effluent is diverted (when necessary) to a small fish pond adjacent to the sedimentation pond.

The chemical and biological sampling points associated with the Thompson site are shown in Figure 3. Table 9 lists the chemical data collected during the four sampling periods.

CHEMICAL EVALUATION

Cleaning operations were underway at the raw water holding pond at the Thompson site during the first sampling round. Since only one holding pond was available at this site, a temporary makeshift treatment procedure, not indicative or normal plant procedure, was in operation at the time of visit. The portion of the raw water discharge which exceeded the capacity of the treatment plant was pumped directly (without treatment) to the sedimentation pond. This raw water was then combined in this pond with the treated effluent discharged by the plant. The end result of this activity was a final discharge which exhibited an acidity concentration of 115 mg/l and carried a total iron concentration of 50 mg/l. During the sample period, the background alkalinity of 177 mg/l in the receiving stream was totally depleted with a resultant acidity concentration of 63 mg/l.

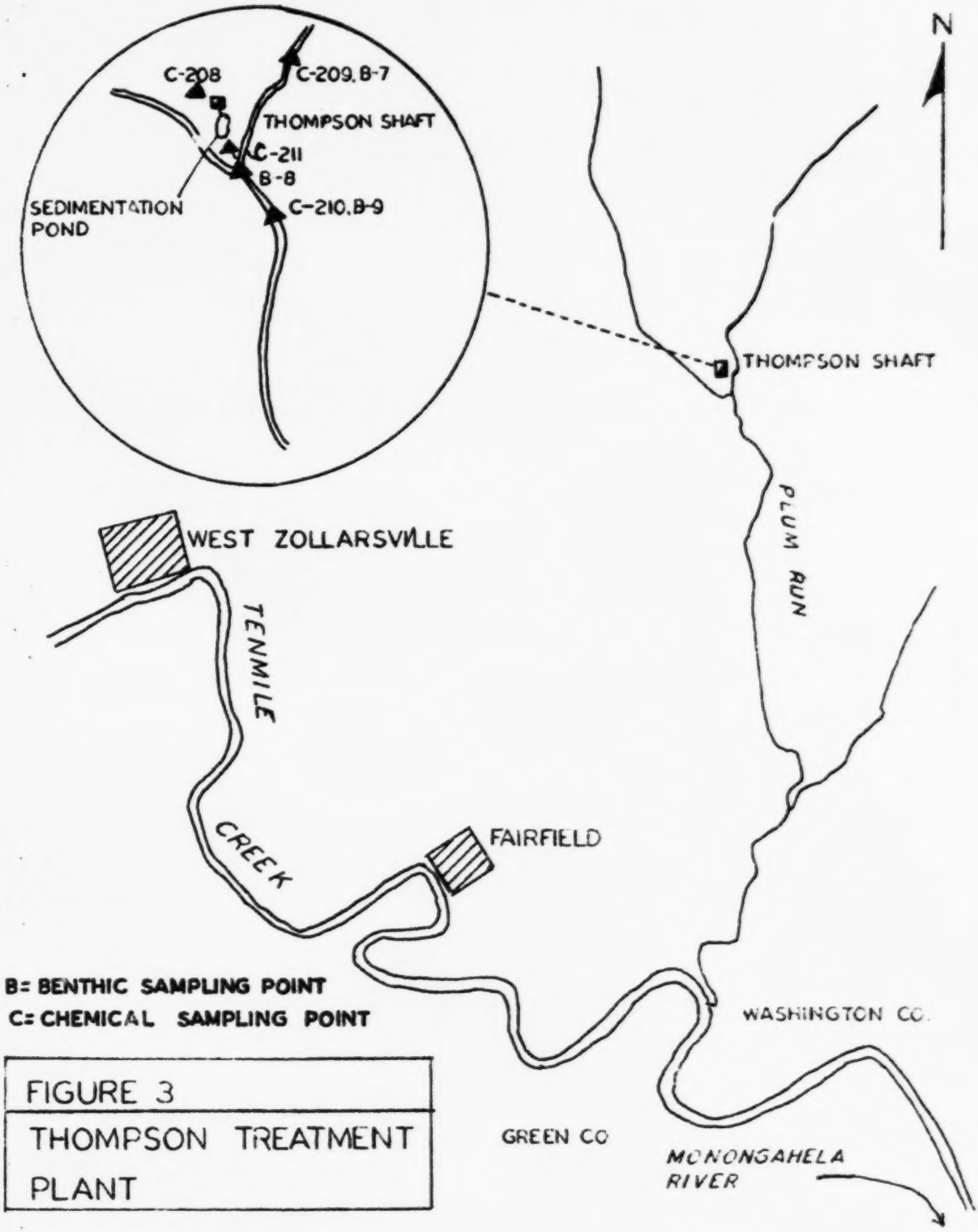


FIGURE 3

THOMPSON TREATMENT PLANT

Table 9

Water Quality Data

Thompson Treatment Plant

	Background (C-209)				Untreated Discharge (C-208)				Treated Discharge (C-211)				Downstream (C-210)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
pH	7.8	7.2	7.6	7.8	3.2	3.4	3.1	3.1	8.0	7.2	7.3	7.6	6.9	7.5	7.5	7.4
Specific Conductance	750	1000	1000	1100	8000	5500	6000	5000	6000	5550	6000	4500	1100	1700	1900	2800
Flow-gpm	-	-	-	-	-	-	-	-	-	114	129	100	1531	833	858	-
Net Alkalinity-mg/l	177	110	186	186	1300*	-940*	-760*	-585*	-115*	7	35	43	-63*	103	163	144
Dissolved Iron-mg/l	0	0.5	0	0	100	100	160	100	50	0.3	0.5	0.5	1	0.3	0	0.2
Suspended Iron-mg/l	0.7	0.5	0	0.2	50	0	0	10	0	0.7	0	1.5	0	0.2	0	0.3
Total Iron mg/l	0.7	1.0	0	0.2	150	100	160	110	50	1	0.5	2.0	1	0.5	0	0.5
Sulfate mg/l	140	280	440	260	4000	2450	2150	2350	3450	2200	1700	1845	180	480	610	780
Manganese mg/l	-	0.2	1	0	-	5	0	5	-	1.5	0	2	-	0.5	2	1
Aluminum mg/l	-	0	0	0	-	45	50	55	-	0	0	0	-	0	0	0

*Negative value denotes acidity.

Table 9 (continued)

Water Quality Data

Thompson Treatment Plant

	Background (C-209)				Untreated Discharge (C-208)				Treated Discharge (C-211)				Downstream (C-210)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
Calcium mg/l	-	75	75	120	-	300	200	480	-	400	600	781	-	50	170	240
Magnesium mg/l	-	25	25	35	-	135	75	80	-	50	50	61	-	50	30	43
Cadmium ug/l	-	0	0	18	-	20	20	650	-	10	20	33	-	10	20	50
Chromium ug/l	-	0	20	0	-	40	40	57	-	0	30	10	-	0	20	10
Copper ug/l	-	0	0	0	-	100	5000	170	-	0	0	50	-	0	0	40
Lead ug/l	-	0	0	20	-	20	0	20	-	20	0	40	-	5	0	20
Nickel ug/l	-	20	0	20	-	500	200	600	-	60	80	200	-	20	0	73
Zinc ug/l	-	20	20	17	-	700	900	620	-	20	20	33	-	40	10	50

The following comments relate to the three subsequent sampling rounds at the Thompson plant when it was operating under normal conditions.

The Thompson raw water discharge carried average acid and iron concentrations of 762 mg/l and 123 mg/l, respectively. The aluminum concentration averaged 50 mg/l. The presence of trace metals, including cadmium, chromium, copper, nickel and zinc were detected on each of the three occasions which analyses for these metals were performed. Lead was present on two of the three occasions. After treatment, the high initial acidity was converted to a net alkalinity averaging 28 mg/l. The initial average total iron concentration (123 mg/l) was reduced to an average concentration of only 1.2 mg/l. The aluminum present in the raw water was completely removed by the treatment process. Zinc was the only trace metal which was significantly reduced by the treatment process. An initial average concentration of 740 micrograms per liter was reduced to 24 micrograms per liter in the treated discharge.

Above the Thompson plant, the pH values of the receiving stream ranged from 7.2 to 7.8. Below the Thompson outfall, the stream exhibited pH values ranging from 7.4 to 7.5. At the upstream point, the stream exhibited an average net alkalinity of 161 mg/l. Below the point of discharge, the stream carried an average net alkalinity of 137 mg/l. There was no significant change in the average total iron concentrations measured at the upstream and downstream points.

An average discharge rate of 114 gpm was measured at this site during the survey.

With the exception of the one instance described above, the Thompson plant provided excellent treatment with respect to the upgrading of the water quality exhibited by the final discharge from the facility.

BIOLOGICAL EVALUATION

Descriptions of the three biological sampling stations associated with the Thompson plant are given below. Tables 10, 11 and 12 present the biological data collected at these stations.

The diversity indices at the three stations at this site were gradually reduced from Station B-7 to Station B-9 while the total number of organisms was greatly reduced between Station B-7 and Station B-8, and increased between Station B-8 and Station B-9. The principle taxonomic group collected at the three stations was the dipteran family, Chironomidae. The following is a more detailed description of the results obtained at each station.

Station B-7 (upstream of discharge)

The substrate at this station consisted primarily of rubble which (Table 10) provides a favorable habitat for benthic organisms. A total of 18 taxa and 302 organisms were collected at this station. Fifty-six percent of the organisms collected were in Class I; 19

Table 10
Benthos Sampling Stations
Thompson Treatment Plant

Station No.	Sampling Dates	Station Location	Substrate Description	Comments
B-7	5/17 5/17 to 6/16 6/16 to 7/24 7/24 to 8/21	Plum Run approximately 25 feet above the discharge.	Riffle Areas* 5% rock 45% rubble 10% C.Gravel 10% F.Gravel 10% F.Sand 20% clay Pool Areas A mixture of bedrock, fine silt and some clay.	One dendy collected on 7/24 was partially silted in.
B-8	5/17 5/17 to 6/16 6/16 to 7/24 7/24 to 8/21	Plum Run approximately 40 feet below the discharge.	Riffle Areas 10% rock 10% C.Gravel 10% F.Gravel 30% C.Sand 40% F.Sand Pool Areas A mixture of bedrock, fine silt and some clay.	One dendy collected on 7/24 was partially out of the water because of low flow.
B-9	5/17 5/17 to 6/16 6/16 to 7/24 7/24 to 8/21	Plum Run approximately 200 yards below the discharge.	Riffle Areas 20% rubble 10%C.Gravel 10% F.Gravel 30% C.Sand 20% F.Sand Pool Areas Mostly bedrock with some silt.	

*Bottom compositions are estimates based on field observations.

Table 11
Benthos Data Summary
Thompson Treatment Plant

Station Number	Sampling Dates	No. of Samples	Type of Samples	Total No. of Organisms	No. of Taxa Collected	Diversity Index	%of Class I	% of Class II	% of Class III
B-7	5/17	1	S*	302	18	2.98	56	19	25
	5/17 to 6/16	1	D**	47	4	0.78	2	2	96
	5/17 to 6/16	1	D	38	2	0.27	0	3	97
	6/16 to 7/24	1	D	33	4	0.86	3	9	88
	6/16 to 7/24	1	D	38	4	0.82	3	50	47
	7/24 to 8/21	1	D	18	1	Ø	0	0	100
	7/24 to 8/21	1	D	32	3	0.58	3	3	94
	5/17	1	S	95	12	2.42	14	34	52
	5/17 to 6/16	1	D	99	6	1.08	6	4	90
	5/17 to 6/16	1	D	37	3	0.55	3	0	97
	6/16 to 7/24	1	D	11	1	Ø	0	0	100
	7/24 to 8/21	1	D	8	3	0197	0	25	75
B-9	5/17	1	S	210	12	2.06	28	24	48
	5/17 to 6/16	1	D	41	5	1.08	2	10	88
	5/17 to 6/16	1	D	28	5	1.20	7	4	89
	6/16 to 7/24	1	D	28	1	Ø	0	0	100
	6/16 to 7/24	1	D	32	1	Ø	0	0	100
	7/24 to 8/21	1	D	13	1	Ø	0	0	100
	7/24 to 8/21	1	D	81	5	0.91	1	5	94

* Surber Samples
** Artificial Substrate Samples

Table 12
Benthos Data
Thompson Treatment Plant

Class I	B-7a	B-7b	B-7b	B-7c	B-7c	B-7d	B-7d	B-8a	B-8b	B-8b	B-8c	B-8d	B-9a	B-9b	B-9b	B-9c	B-9c	B-9d	B-9d
Caddisflies																			
Hydroptilidae	65							1					53						
Philopotamidae	26												1						
Stoneflies																			
Perlidae	27	1											5						
Perlodidae	3																		
Crustaceans																			
Astacidae								2	1	1				1	1				
Isopoda	42							2											
Flatworms																			
Turbellaria	3						1	4	5										
Fingernail Clams																			
Sphaeriidae	1				1			3											
Crane Flies																			
Tipulidae	1												1						
Coelenterata[a]																			
Hydridae		-*							-	-					-				
Leeches																			
Hirudinea				1				1							1			1	
Class II																			
Caddisflies																			
Hydropsychidae	9		1					8					19	2				1	
Stoneflies																			
Nemouridae[e]	2												2						

*The number of these organisms were not counted.

Table 12
Benthos Data
Thompson Treatment Plant

· continued

Class II (cont'd)	B-7a	B-7b	B-7b	B-7c	B-7c	B-7d	B-7d	B-8a	B-8b	B-8b	B-8c	B-8d	B-9a	B-9b	B-9b	B-9c	B-9c	B-9d	B-9d
Mayflies																			
Baetidae	2							1											2
Biting Midge																			
Ceratopogonidae													2						
Beetle Larvae																			
Elmidae	17			1	4			12					23						
Dryopidae													1						
Dystiscidae														1					
Crustaceans																			
Amphipoda	6												1						
Snails																			
Pulmonata	1																		
Black Flies																			
Simuliidae	2							1											
Dance Flies																			
Empididae	1												2						
Shore Flies																			
Ephydridae												1							
Dragonfly																			
Aeshnidae									1					1					
Damselfly																			
Agrionidae							1												
Aquatic Worms																			
Oligochaeta	18	1		2	15			10	3			1			1				1
Class II																			
Midge Flies																			
Chironomidae	76	45	37	29	18	18	30	50	89	36	11	6	100	36	25	28	32	13	76

percent in Class II and 25 percent in Class III (Table 11). The majority of the organisms were in seven taxonomic groups and, of these seven groups, four were in Class I. The composition of the benthic community at this station was considered representative of unpolluted water.

Station B-8 (40 feet below discharge)

Sand was the principle constituent of the substrate at this station (Table 10). There was very little rock and no rubble for the attachment of macroinvertebrates. This poor substrate may be partially responsible for the results obtained at this station. The substrate in this particular stretch of Plum Run had very light red stains on it from iron precipitates. The composition of the benthic community was primarily midge larvae which made up 52 percent of the total (Table 11). All classes of organisms were reduced in numbers (Figure 5) and the most drastic reduction was within Class I where the number dropped from 168 organisms at Station B-7 to 13 organisms at this station. The diversity index was lower at this station (Figure 6) than the index at B-7 and the number of taxa was also less. The benthic community at this station was represented by organisms capable of tolerating both pollution and a poor substrate.

Station B-9 (200 yards below the discharge)

The substrate at this station was somewhat improved over that encountered at Station B-8. Approximately 30 percent of the bottom

consisted of rubble (Table B-10). Although rubble creates a desirable habitat for the development of a diverse benthic community, the overall results do not reflect this. The total number of organisms collected at this station was 210 (Figure 6) as compared to the 95 organisms collected at Station B-8. This increase of 115 organisms is due to the increase in the number of the family Hydroptilidae and the family Chironomidae. The number of Hydropsychidae and Elmidae also increased but not in numbers approaching those of the Hydroptilidae and Chironomidae. The total number of taxa collected at this station was the same as collected at Station B-8; however, there was a decrease in the number of Class I taxa and an increase in the number Class II. The diversity index (2.06) was lower than the diversity index at Station B-8 (2.42). The increase in total number at Station B-9 was the cause of this reduced diversity index.

CONTROL STATION - LYNCH BOREHOLE

This station was located on Little Indian Creek, a tributary to Indian Creek which joins the Monongahela River at Everettville, West Virginia. The source of mine water discharge at this site was the Lynch Borehole from the Arkwright No. 1 Mine operated by Consolidation Coal Co. The effluent from this borehole was representative of a grossly polluted mine drainage discharge. The mine effluent was pumped to a small equilization pond and then flowed directly to Little Indian Creek without any treatment.

Samples for chemical and biological analyses were collected from a point above the discharge (C-212, background), 150 yards below the discharge, and 0.9 mile below the discharge. There was no actual sampling of the Lynch Borehole during the survey period. However, samples of the Lynch Borehole were collected as part of the overall inventory of all active underground mines in the Monongahela River basin mentioned earlier in this document. These samples were collected during March, September and October of 1972. This information is presented in Table 13.

Little Indian Creek is unaffected by any type of mine drainage discharge above the Lynch Borehole. There is one abandoned mine a short distance above (upstream) the furthest downstream sampling point (C-214). There was no visible discharge from this mine during the period of survey; however, samples were collected from the unnamed receiving stream on which the mine is located in order to document the lack of any significant mine drainage contribution from this site. Chemical data for the control site are presented in Table 14.

CHEMICAL EVALUATION

Little Indian Creek, above the Lynch Borehole, exhibited pH values ranging from 6.7 to 7.6 and carried an average alkalinity concentration of 117 mg/l. The average total iron concentration at this point was 1.6 mg/l and the average sulfate concentration was less than 50 mg/l. Trace metals were detected in minute quantities.

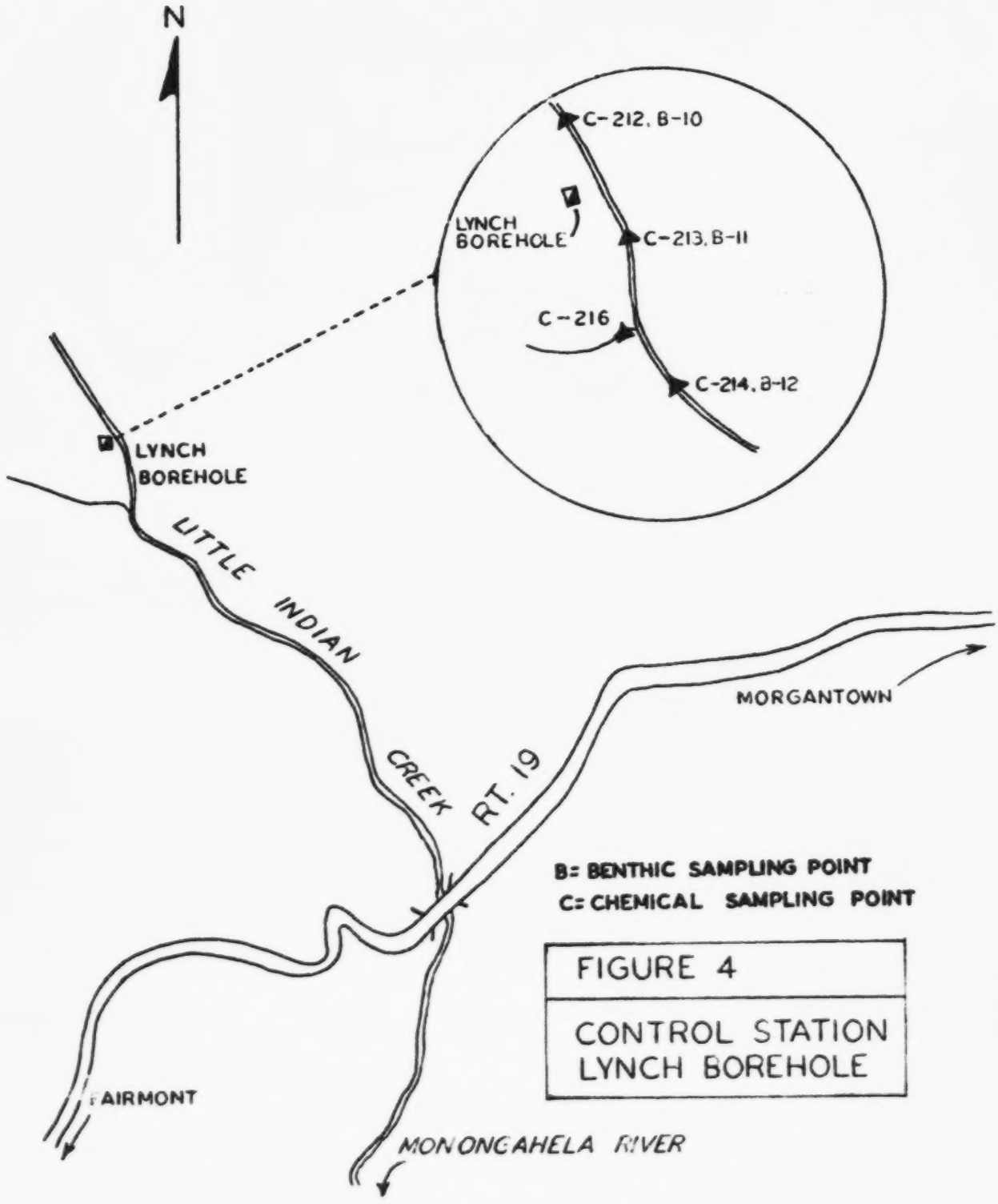


FIGURE 4

CONTROL STATION
LYNCH BOREHOLE

Table 13

Water Quality Data

Lynch Borehole Discharge

Date	3/72	9/72	10/72
pH	2.6	3.0	3.4
Net Acidity mg/l	6160	5725	-
lb/day	(1,550)	(687)	
Total Iron mg/l	1600	2300	2700
lb/day	(403)	(276)	(1650)
Sulfates mg/l	11,500	5,500	-
lb/day	(2898)	(660)	
Flow (gpm)	21	10	51

Table 14
Water Quality Data
Control Site

	Indian Creek (C-212) Background				Little Indian Creek (C213) 150 yds. below discharge				Unnamed Tributary (C-216) to Little Indian Creek				Little Indian Creek (C21 0.9 mi. below discharge			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
pH	6.7	7.2	7.3	7.6	2.6	3.2	2.7	2.8	6.6	6.7	7.3	7.5	3.4	3.5	3.0	2.9
Specific Conductance	440	400	400	520	3000	3500	3200	5500	340	300	280	340	2500	2400	2200	3500
Flow-gpm	-	-	-	-	-	-	-	-	-	-	-	-	315	-	202	-
Net Acidity mg/l	-71*	-90*	-152*	-155*	930	1320	1180	2165	140	1	-25*	-15*	600	715	515	1055
Dissolved Iron-mg/l	0.3	0.5	0	0.5	100	100	75	660	-	-	-	-	100	100	20	300
Suspended Iron-mg/l	2.7	0	0	2.5	20	100	0	60	-	-	-	-	0	0	0	20
Total Iron mg/l	3.0	0.5	0	3	120	200	75	720	2	4	5	5	100	100	20	320
Sulfate mg/l	60	40	40	45	1505	1250	1530	1900	50	50	650	90	930	1040	700	1540
Manganese-mg/l	-	0.2	3	0	-	3	4	6	-	0.2	-	-	-	3	4	4
Aluminum-mg/l	-	0	0	0	-	70	60	130	-	0	-	-	-	45	40	80
Calcium-mg/l	-	20	40	50	-	100	100	180	-	17	-	-	-	50	70	130
Magnesium-mg/l	-	8	15	11	-	50	50	100	-	5	-	-	-	35	25	53

*negative value denotes alkalinity

Table 14
Water Quality Data
Control Site

(continued)

	Indian Creek (C-212) Background				Little Indian Creek (C213) 150 yds. below discharge				Unnamed Tributary (C-216) to Little Indian Creek				Little Indian Creek(C214 0.9 mi. below discharge			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
Cadmium ug/l	-	0	0	20	-	5	0	3800	-	0	-	-	-	5	0	1700
Chromium ug/l	-	0	20	0	-	70	50	85	-	10	-	-	-	60	40	400
Copper ug/l	-	0	0	20	-	300	10,000	600	-	0	-	-	-	200	4000	35
Lead ug/l	-	0	0	10	-	20	0	30	-	0	-	-	-	20	0	20
Nickel g/l	-	0	80	10	-	600	250	1500	-	30	-	-	-	500	100	860
Zinc ug/l	-	20	0	25	-	1200	1600	2500	-	40	-	-	-	700	600	1400

The pH values of the Lynch discharge ranged from 2.6 to 3.4 with an average acidity concentration of nearly 6,000 mg/l. The total iron concentration averaged 2,200 mg/l.

The water quality of Little Indian Creek was highly degraded at Station No. 213, located approximately 150 yards below the Lynch Borehole. At this point, the pH values ranged from 2.6 to 3.2 with an average acidity concentration of 1,399 mg/l. Average concentrations of total iron and sulfates had increased to 279 mg/l and 1,546 mg/l, respectively. Trace metals including zinc, copper, cadmium and nickel were detected in concentrations exceeding 1,500 micrograms per liter.

The unnamed tributary which enters Little Indian Creek between Station No.'s C-213 and C-214 was a relatively insignificant contributor of additional iron and acidity. The pH values of this stream ranged from 6.6 to 7.5. On one occasion, the stream was acid (140 mg/l); however , on subsequent samplings, the acidity concentration was either minimal (1 mg/l) or totally absent. The stream carried an average total iron concentration of 4 mg/l.

Station No. C-214 was located on Little Indian Creek approximately 0.9 miles below the Lynch Borehole discharge. Stream improvement, with respect to water quality, was negligible at this downstream point. The pH values of the stream ranged from 2.4 to 3.5 with an average acidity concentration of 721 mg/l. Average concentrations of total iron and sulfates were 135 mg/l and 1,052 mg/l, respectively. Trace metals, including copper, zinc and cadmium, were detected in appreciable concentrations at this point.

BIOLOGICAL EVALUATION

Descriptions of the three biological sampling stations associated with the control site are given below. Tables 15, 16 and 17 present the biological data collected at these stations.

The samples collected at this site demonstrates the chronic toxicity of untreated mine drainage to most organisms. The relatively healthy upstream benthic community was totally absent at both downstream stations.

Station B-10 (upstream of discharge)

Little Indian Creek in this reach is very small. The mouth of the benthic sampler spanned the entire width of the riffle. The substrate was composed of gravel and sand (Table 14). The bottom fauna collected at this station was predominantly sensitive organisms (Figure 5).

Thirty-nine percent of the organisms were in Class II and only three percent of the organisms were in Class III. The fifty-eight Heptageniidae (Table 15) accounted for greater than 50 percent of all organisms collected at this station. Although the organisms were not evenly distributed among the taxonomic groups, the stream supported an aquatic fauna indicative of good water quality.

Station B-11 (150 yards below discharge)

The water quality and the substrate were seriously degraded at this station. The stream bottom was completely encrusted with

Table I5
Benthos Sampling Stations
Control Site

Station No.	Sampling Dates	Station Location	Substrate Description	Comments
B-10	5/25 5/25 to 6/22 6/22 to 7/25 7/25 to 8/22	Little Indian Creek approximately 50 yards above the discharge.	Riffle Areas* 20% Rubble 10% C.Gravel 20% F.Gravel 20% C.Sand 20% F.Sand 10% Silt Pool Areas Bottoms consisted mostly of mud and silt	
B-11	5/25 5/25 to 6/22 6/22 to 7/25 7/25 to 8/22	Little Indian Creek approximately 150 yards below the discharge.	Riffle Areas 20% C.Gravel 10% F.Gravel 20% C.Sand 20% F.Sand 30% "Yellow Boy" Pool Areas Gravel and "Yellow Boy"	The bottom in this area was encrusted with iron precipitates. There was also a lot of iron precipitates in suspension
B-12	5/25 5/25 to 6/22 6/22 to 7/25 7/25 to 8/22	Little Indian Creek 0.9 miles below the discharge.	Riffle Areas 10% Rock 20% C.Gravel 20% F.Gravel 15% C.Sand 15% F.Sand 20% "Yellow Boy" Pool Areas Bedrock and "Yellow Boy"	Iron precipitates were in suspension.

*Bottom compositions are estimates based on field observations.

Table 16
Benthos Data Summary
Control Site

Station Number	Sampling Dates	No. of Samples	Type of Samples	Total No. of Organisms	No. of Taxa Collected	Diversity Index	%of Class I	% of Class II	% of Class III
B-10a	5/25	1	S*	111	12	2.34	55	39	3
B-10b	5/25 to 6/22	1	I**	118	4	0.63	1	12	87
B-10c	5/25 to 6/22	1	D	94	3	0.45	6	39	55
B-10d	6/22 to 7/25	1	D	64	4	0.72	14	59	27
B-10e	6/22 to 7/25	1	D	82	2	0.23	0	4	96
B-10i	7/25 to 8/22	1	D	66	6	1.15	3	22	75
B-10f	7/25 to 8/22	1	D	7	1	0	0	0	100
B-11a	5/25	1	S	1	1	0	0	0	100
B-11b	5/25 to 6/22	1	D	1	1	0	0	100	0
B-11c	5/25 to 6/22	1	D	2	1	0	0	0	100
B-11d	6/22 to 7/25	1	D	0	0	0	0	0	0
B-11e	6/22 to 7/25	1	D	1	1	0	0	0	100
B-11i	7/25 to 8/22	1	D	0	0	0	0	0	0
B-11f	7/25 to 8/22	1	D	0	0	0	0	0	0
B-12a	5/25	1	S	1	1	0	0	0	100
B-12b	5/25 to 6/22	1	D	2	1	0	0	0	100
B-12c	5/25 to 6/22	1	D	1	1	0	0	0	100
B-12d	6/22 to 7/25	1	D	2	2	0	0	0	100
B-12e	6/22 to 7/25	1	D	0	1	0	0	0	100
B-12i	7/25 to 8/22	1	D	1	1	0	0	0	100
B-12f	7/25 to 8/22	1	D	11	2	0	0	0	100

* S = Sediment
** I = Initial Community Sample

Table 17
Benthos Data
Control Site

Class I	B-10a	B-10b	B-10b	B-10c	B-10c	B-10d	B-10d	B-11a	B-11b	B-11b	B-11c	B-11c	B-11d	B-11d	B-12a	B-12b	B-12b	B-12c	B-12c	B-12d	B-12d
Caddisflies																					
Hydroptilidae	4																				
Stoneflies																					
Perlodidae	1																				
Mayflies																					
Heptageniidae	58																				
Crustaceans																					
Astacidae		1																			
Flatworms																					
Turbellaria	1																				
Fingernail Clams																					
Sphaeriidae	1																				
Coelenterata																					
Hydridae						-*															
Leeches																					
Hirudinea			5		9		2														
Class II																					
Caddisflies																					
Hydropsychidae	7																				
Stoneflies																					
Nemouridae	16																				

*The numbers of these organisms were not counted.

Table 17
Benthos Data
Control Site

Continued

Class II (cont'd)	B-10a	B-10b	B-10b	B-10c	B-10c	B-10d	B-10d	B-11a	B-11b	B-11b	B-11c	B-11c	B-11d	B-11d	B-12a	B-12b	B-12b	B-12c	B-12c	B-12d	B-12d
Mayflies																					
Baetidae	13					2															
Beetle Larvae																					
Elmidae	2																				
Dytiscidae		1																			
Snails																					
Pulmonata	3			1		6															
Aquatic Worms																					
Oligochaeta	2	13	33	37	3	9			1												
Class III																					
Midge Flies																					
Chironomidae	3	103	46	17	79	57	7	1		2		1			1	3	23	5	8	2	11

iron precipitates creating an almost uninhibitable substrate. The pools in this area were filled with flocculent iron precipitates except for a channel large enough for the water to pass through. A single Chironomidae was collected in the sample at this station. An aquatic worm (Table 16) collected on an artificial substrate was the only taxonomic group collected except the midge. A few midge were also collected on the artificial substrates.

Station B-12 (0.9 miles below discharge)

Chemical analyses indicated the water quality at this station was slightly improved over the water quality found at Station B-11. The substrate was also somewhat improved. The stream bottom was not encrusted as severely as at Station B-11, and the basic bottom constituents were more coarse creating a more inhabitable substrate. However, the aquatic fauna at this station was represented only by Chironomidae.

DISCUSSION

The amount of data obtained from the artificial substrates was insufficient to provide a basis for valid conclusions. This ineffectiveness of the multi-plate artificial substrates can be attributed to the exposure period. The artificial substrates were placed in deep riffles, pools, on the bottom, suspended well above the bottom, both horizontally and vertically oriented. The four week exposure periods used for this study were not long enough for the colonization of the macroinvertebrates. It has been shown (Fullner (6)) that macroinvertebrates will colonize an artificial substrate, similar to the one used in this study, sufficiently in 8-10 weeks to obtain reliable results. Fullner's study was conducted on a large river compared to the small streams sampled during this study but this should not significantly affect the colonization of the artificial substrates.

The single bottom sample collected at each of the twelve stations was used almost exclusively for evaluating the four weeks. Statistically, a single bottom sample is not totally adequate for making a biological evaluation of a given stream reach; however, these data are much more reliable than the artificial substrate data.

The level of taxonomic identification affects the quantification of organisms into their respective tolerance groups. Taxa

were placed in Class I if the literature and data indicated that most members of that group were sensitive to mine drainage. Taxa were placed in Class II if most members of that group demonstrated some tolerance to mine drainage. The family level of identification for the crustaceans and insects becomes critical for the Class II organisms because a family is placed in Class II if only one genus or species of that family is facultative. The families Sialidae and Chironomidae have repeatedly demonstrated that they are predominantly tolerant to mine drainage and, therefore are placed in Class III.

BERLIN TREATMENT PLANT

This treatment plant was the most ineffective of the three facilities studied. The benthic community was severely depressed immediately below the discharge and only slightly improved well below the discharge. There were several factors impairing the effectiveness of this treatment plant. The size of the receiving stream was of prime importance and for low flow periods represents nearly the entire flow of the receiving stream. In other words, there is no significant dilution of this discharge by the receiving stream. This discharge would not affect the biota of a large stream nearly as much as it affected this unnamed tributary of Pike Run.

As mentioned earlier, the Bercik facility had been upgraded by the addition of a limer and an electrical aerator shortly before this plant was selected for study. However, due to the accumulation of sludge material in the ponds and the reduced retention time, it appears doubtful that any significant improvement occurred in the water quality of the final effluent. In March 1973, Jones and Laughlin Steel Corporation reported that a sludge removal program would be initiated at the Bercik facility. The end result of this operation, in connection with the upgraded treatment procedure, should result in the production of a final effluent exhibiting improved water quality. This is of particular importance with respect to the increased efficiency in the removal of suspended iron. This suspended iron represented the major portion of the total iron concentration and was primarily responsible for the poor aesthetic appearance of a downstream portion of the receiving stream.

KEFOVER TREATMENT PLANT

The Kefover Treatment Plant is the most efficient treatment plant of the three studied. As the results demonstrate, the benthos at this site were somewhat adversely affected but not to the extent that they were at the two other treatment plants. The retention time in the settling pond and the dilution factor of the

receiving stream are the principal features of this treatment plant. The plant is relatively new and has not had time to build up large quantities of sludge in the settling pond, thus giving the tr ated water an adequate settling period. The receiving stream is larger than the discharge and dilutes the remaining chemical constituents of the discharge to a tolerable level.

Copper and zinc were significantly reduced by the Kefover Treatment Plant. These metals were reduced from an average initial concentration of 88 ug/l and 527 ug/l to an average of 8 ug/l and 103 ug/l, respectively. An initial aluminum concentration was completely removed by the treatment procedure on both occasions when initially present.

THOMPSON TREATMENT PLANT

From the chemical standpoint and under normal operation conditions, this plant is as effective as the Kefover Treatment Plant. However, slugs of acid water are apparently released, on occasion, from this plant and reduce its overall treatment capability. These slugs occur when sludge is being pumped from the raw water holding pond. When the raw water pond is being cleaned, the raw water is pumped to the treated water settling pond and mixed with water that has been treated. This mixture of treated and untreated water then discharges to the receiving stream. The plant was operating under

these conditions during the first sample collection.

If there were no slugs released from this plant, its effectiveness would probably be equal to that of the Kefover Treatment Plant.

An average initial aluminum concentration of 50 mg/l was completely removed by the treatment procedure. Similar significant reductions were apparent for nickel and zinc and, to a lesser degree, for several other trace metals.

CONTROL STATION - LYNCH BOREHOLE

As previously mentioned, the discharge from this borehole severely degrades the water quality of Little Indian Creek and nearly eliminates all macroinvertebrates. The data collected from the study area at this site demonstrates the effects of an untreated discharge upon the stream water quality and the benthos of the receiving stream.

FIGURE 5

Benthos Collections

Class Composition for Surber Samples

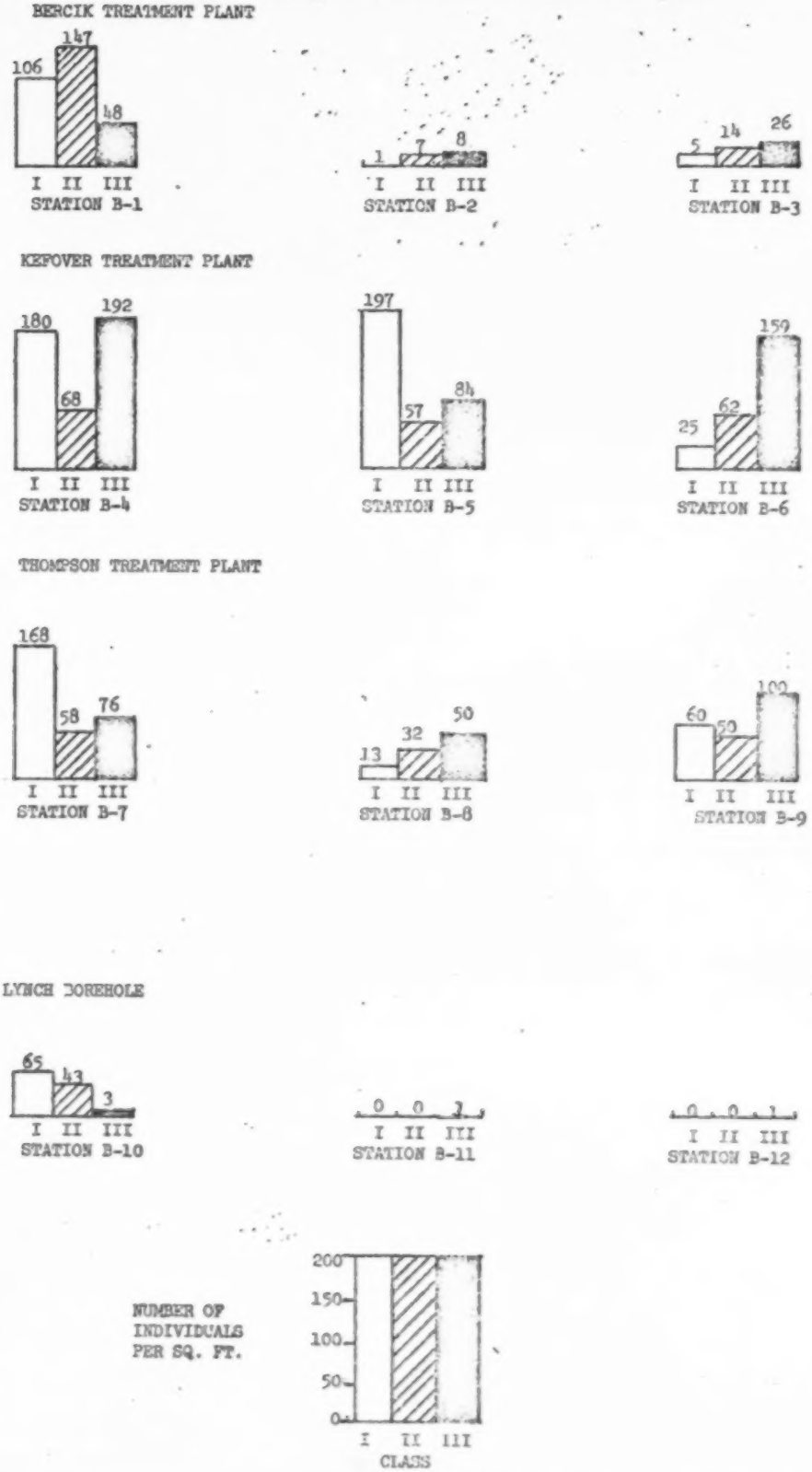
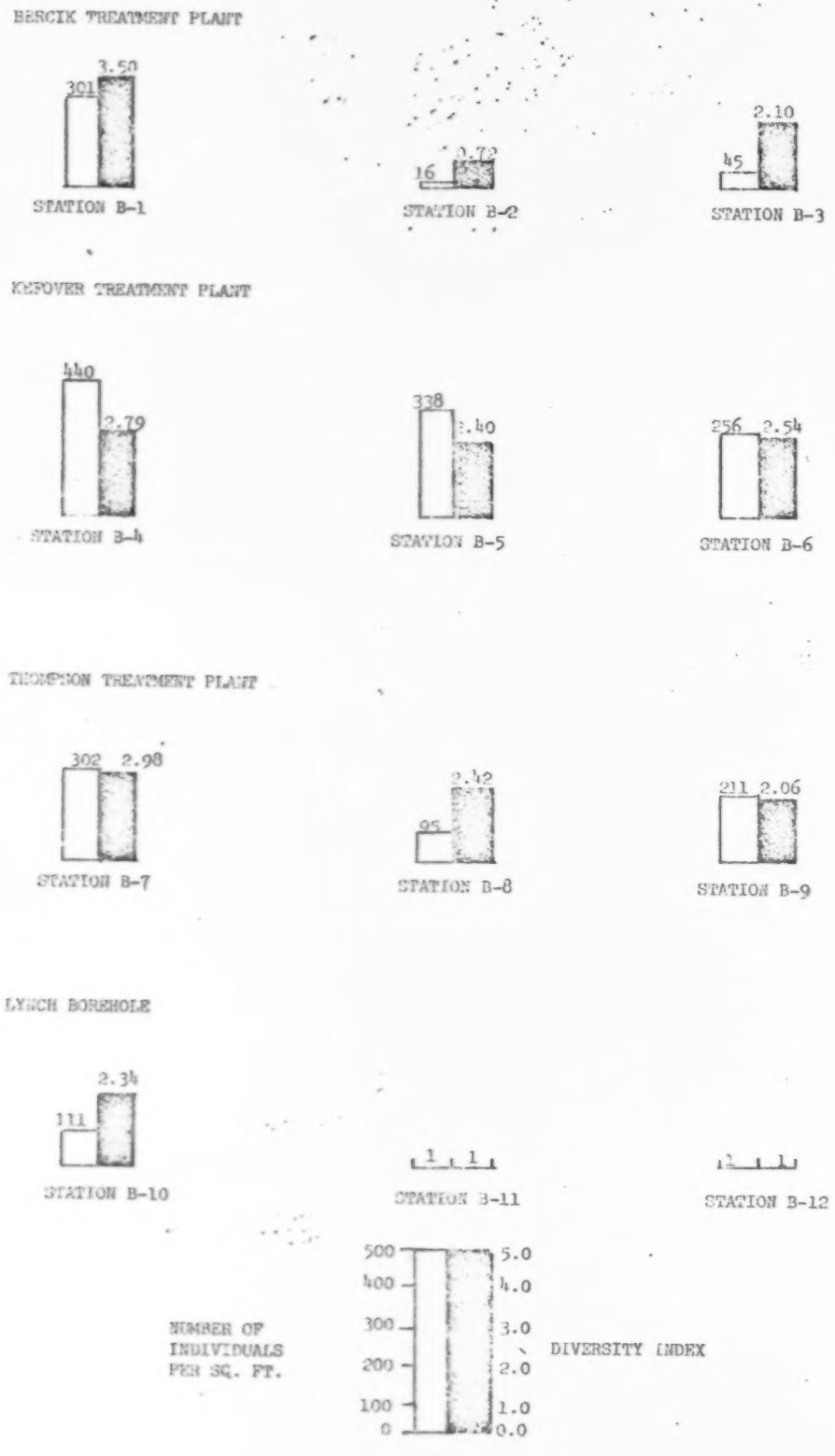


FIGURE 6
Benthos Collections
Density and Diversity Index Values for the Surber Samples



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